



INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(51) International Patent Classification ⁵ : C22B 3/42, 11/08	A1	(11) International Publication Number: WO 91/11539 (43) International Publication Date: 8 August 1991 (08.08.91)
(21) International Application Number: PCT/GB91/00114 (22) International Filing Date: 28 January 1991 (28.01.91) (30) Priority data: 9002311.0 2 February 1990 (02.02.90) GB (71) Applicant (for all designated States except US): DAVY McKEE (STOCKTON) LIMITED [GB/GB]; Ashmore House, Stockton-on-Tees, Cleveland TS18 3RE (GB). (72) Inventors; and (75) Inventors/Applicants (for US only) : LULHAM, Jonathan, Paul [GB/GB]; 61 Montford Road, Sunbury on Thames, Middlesex TW16 6EJ (GB). LINDSAY, Derek [GB/GB]; 36 Whittaker Lane, Prestwich, Manchester. M25 5FX (GB).		(74) Agent: EYLES, Christopher, Thomas; W.P. Thompson & Co., 52-54 High Holborn, London WC1V 6RY (GB). (81) Designated States: AT (European patent), AU, BE (European patent), BR, CA, CH (European patent), DE (European patent), DK (European patent), ES (European patent), FR (European patent), GB (European patent), GR (European patent), IT (European patent), LU (European patent), NL (European patent), SE (European patent), US. Published <i>With international search report. Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: SEPARATION PROCESS (57) Abstract <p>A process is described for the recovery of gold from gold-loaded thiosulphate solution. The solution is treated with at least a stoichiometric amount of cyanide ions and the resultant gold complex is adsorbed by an adsorbent, such as carbon or a resin. The gold loaded adsorbent is then subjected to stripping to recover adsorbed gold. The process is surprisingly effective in separating gold from thiosulphate solutions which are normally difficult to treat.</p>		

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SEPARATION PROCESS

The present invention relates to the recovery of metals from solution and more particularly relates to the recovery of gold from leach solutions.

It is common for gold or precious metals to be separated from their ores by treatment with cyanide solutions, the metal forming a soluble complex with the cyanide and being subsequently extracted from solution. However, certain gold-bearing ores (referred to generally as refractory ores) are not amenable to cyanidation and include pyritic and arsenopyritic ores.

A number of cyanide extraction processes for extracting gold from refractory ores are known. These are directed towards the breakdown of the sulphur matrix and the removal of the gold in a solubilised form from which it may subsequently be retrieved. Such techniques include roasting of the ground ore followed by cyanidation or acid pressure leaching with sulphuric acid and oxygen at about 200°C followed by cyanidation of the neutralised residue.

A process has also been proposed for the leaching of precious metals from arsenopyritic, pyritic or related ores by treatment of the ore with an alkaline solution while bubbling oxygen containing gas through the mixture to break up the matrix. Such a process is described in EP-A-0316094.

A further alternative for recovery of precious metals, such as gold, from their ores involves treatment of the ore with a thiosulphate solution. For example, US-A-4070182 teaches a process for the recovery of gold from copper bearing sulphidic material containing gold. The copper bearing sulphidic material is subjected to a main leach under oxidising conditions to provide a copper containing main leach liquor and a main residue. This residue, or the copper bearing sulphidic material before the main leach, is subjected to a secondary leach with ammonium

thiosulphate solution to provide a gold containing secondary leach liquor and a secondary residue. Cementation with zinc is said to provide a commercially useful and effective method of precipitating the precious metals from solution, preferably after first reducing cupric ions in the solution to cuprous ions, for example by reaction with sulphur dioxide. According to column 1, lines 38 to 68 of US-A-4269622 problems arise due to the instability of the thiosulphate ion in this process. Thus US-A-4269622 teaches a process for recovery of precious metals such as gold and silver from ores that are difficult to treat, particularly those containing manganese, by lixiviating using an ammonium thiosulphate leach solution containing copper, sufficient ammonia to maintain a pH of at least 7.5, and at least 0.05% sulphite ion. Proposed methods of recovery of the precious metals from the leach solution are use of metallic zinc, iron or copper, of electrolysis or of addition of soluble sulphides to recover a sulphide precipitate. It is said that, with the use of such a leach liquor good recoveries are achieved in less time compared with the prior art use of cyanide, and without the possibility of contamination of streams and surroundings. A development of the process is described in US-A-4369061 wherein the sulphite ion concentration is maintained at at least 0.05% by generation in situ by the addition of sulphur dioxide, and generating thiosulphate in situ as needed by the addition of elemental sulphur to the system.

More recently US-A-4778519 has disclosed a method for recovery of gold and silver from precious metal bearing materials, including ores, with a thiourea solution to form a thiourea leach which is then contacted with carbon to absorb the gold and silver and provide loaded carbon. The precious metals are then separated from the carbon by contacting the loaded carbon, with thiosulphate ions.

The present invention seeks to provide an improved process for the recovery of gold from thiosulphate containing solutions, for example those obtained from leaching of refractory ores.

According to the present invention there is provided a process for the recovery of gold from gold-loaded thiosulphate solution comprising the steps of (a) adding to the solution at least a stoichiometric amount of cyanide ions (relative to gold) (b) adsorbing the resultant gold cyanide complex on an adsorbent and (c) separating the adsorbed gold from the adsorbent.

In a gold extraction process the concentration of gold in a typical thiosulphate leach liquor may be measured in terms of a few mg per litre of liquor. Hence very low concentrations of gold are normally present in the leach liquor. Moreover, since silver is often present in a gold bearing ore, the leach liquor may contain significant quantities of silver, often in excess of the amount of gold present. Cementation with zinc will normally result in co-precipitation of gold and silver so that subsequent processing steps are required to separate gold from silver.

Carbon is not an effective adsorbent for gold from a typical gold-containing thiosulphate leach liquor, we have found in the course of our experiments. Surprisingly, however, even when the gold-thiosulphate complex ion is present in very low concentrations (e.g. 5 ppm), such as may be encountered in typical gold processing operations, the reaction of cyanide ions with the gold-thiosulphate complex ion proceeds essentially to completion, even though only a stoichiometric or near stoichiometric amount of cyanide is used. It is further surprising that, even though the presence of excess thiosulphate ions in the leach liquor would be expected to displace reaction equilibria in favour of the gold-thiosulphate complex ion, yet the reaction of

cyanide ion in a stoichiometric or near stoichiometric amount still proceeds essentially to completion in the leach liquor. It is also surprising that there does not appear to be any side reaction of the cyanide ion even though added at very low concentrations; in particular it is surprising that the cyanide ions do not react with the excess thiosulphate ions to form thiocyanate (SCN^-) ions. The resulting gold cyanide complex can be efficiently adsorbed from the leach liquor on carbon and subsequently stripped therefrom so that the process of the invention results in very high recovery of gold from the thiosulphate leach liquor. Since only a stoichiometric or near stoichiometric amount of cyanide is added to the leach liquor, the concentration of free cyanide ions in the barren leach liquid resulting after contact with the adsorbent is low and is typically equivalent to only a few mg per litre. Hence the danger of environmental damage by use of cyanide ions is correspondingly low.

Another advantage of the process of the present invention is that the recovery of gold is selective; if the leach liquor also contains other dissolved metals, such as silver, then the selectivity of recovery of gold, compared to silver, is extremely high, even though silver can also form complex metal cyanide ions which are also capable of being adsorption upon an adsorbent, such as carbon. In our experiments we found that the recovery of gold present in the thiosulphate leach liquor was greater than 95%, typically at least about 97% under favourable circumstances, using the process of the invention, whilst less than 1% of the silver present in the thiosulphate leach liquor, typically not more than about 0.5% thereof, is recovered in the stripping step.

The gold-loaded thiosulphate solution may be obtained by treatment of a gold-bearing material, such as an ore, with a thiosulphate solution. Alternatively it can be

obtained by the treatment of an oxidised residue of a refractory ore, such as a pyritic ore or an arsenopyritic ore, with a thiosulphate solution. Another way of producing a gold-loaded thiosulphate solution involves treating a refractory ore, such as a pyritic ore or an arsenopyritic ore, with oxygen and an alkaline solution as taught, for example, by EP-A-0316094; in this case the thiosulphate ions may be generated in situ.

The adsorbent may be any adsorbent that will adsorb a gold cyanide complex from a solution thereof. Typical adsorbents include carbon, preferably activated carbon, or a resin, such as an anion exchange resin.

The adsorbed gold may be separated from the adsorbent, e.g. carbon, by a stripping process such as the Zadra stripping process. Stripping of the loaded carbon with a stripping liquid, such as water, dilute caustic or dilute caustic cyanide, at temperatures above 130°C can be used as described in US-A-3920403.

In the process of the invention cyanide ions may be added in an amount corresponding to from 1 to about 400 times the cyanide:gold stoichiometric ratio. Preferably the amount of cyanide ions added corresponds to no more than about 25 times, e.g. less than 10 times, the cyanide:gold stoichiometric ratio. Even more preferably the amount of cyanide ions added correspond to no more than about twice, e.g. 1.5 times or less, the cyanide:gold stoichiometric ratio. The cyanide ions may be added in any convenient form, for example as an alkali metal cyanide, such as sodium or potassium cyanide.

The gold-loaded thiosulphate solution may contain up to about 6% w/v $\text{Na}_2\text{S}_2\text{O}_3$, typically from about 0.1% w/v up to about 6% w/v, for example from about 1% w/v to about 6% w/v $\text{Na}_2\text{S}_2\text{O}_3$. It may further contain one or more of the following components, viz.:

- (a) up to about 25% w/v Na_2SO_4 , e.g. from about 0.1% w/v up to about 25% w/v, typically at least about 1% w/v, for example from about 15% w/v to 25% w/v Na_2SO_4 ; and/or
- (b) up to about 5% w/v Na_2CO_3 , e.g. from about 0.1% w/v to about 5% w/v Na_2CO_3 ; and/or
- (c) up to about 10% w/v NaOH , e.g. from about 0.1% w/v up to about 10% w/v NaOH .

The gold in the gold-loaded thiosulphate solution is present as the gold thiosulphate complex anion, typically at a concentration of from about 1 to about 10 mg/l, calculated as gold metal.

As mentioned above, silver also forms complex ions by reaction with cyanide ions. Other metals which can form complex ions with cyanide and may be present in gold ores and other gold-bearing materials used for the production of the starting gold-loaded thiosulphate solution include copper and zinc. It is an advantage of the process of the invention that it permits the selective recovery of gold from solutions containing silver and other metals that form complex ions with cyanide. Hence the invention further provides a process for the selective recovery of gold from a thiosulphate-containing feed solution containing at least one further metal selected from silver, copper, zinc and mixtures thereof, comprising the steps of:

- (a) adding to the feed solution at least a stoichiometric amount of cyanide ions relative to gold;
- (b) adsorbing the resultant gold cyanide complex on an adsorbent thereby to produce (i) a gold-loaded adsorbent bearing a substantial proportion of the gold present in the feed solution and at most a minor proportion of said at least one other metal present in the feed solution and (ii) a barren liquor containing substantially all of said at least one other metal present in the feed solution and at most a minor proportion of the gold present in the feed solution;

- (c) separating the gold-loaded adsorbent from the barren liquor; and
- (d) separating the adsorbed gold from the adsorbent.

In such a process, under favourable conditions, the adsorbent may adsorb at least about 90% of the gold present in the gold-loaded solution, up to about 95% or more thereof (e.g. about 97% or more), whilst adsorbing no more than about 10%, and preferably not more than about 5% (even more preferably not more than about 1% or less), of any other dissolved metal, such as silver, copper or zinc, that can form complex anions by reaction with cyanide ions. In this way the subsequent refining of the recovered gold is correspondingly facilitated.

The invention will now be described by way of example only.

400 mls of a solution of 3.32 mg of gold (in the form of the anion $\text{Au}(\text{S}_2\text{O}_3)_2^{3-}$) per litre of water was stirred with 10 g of activated carbon at 25°C for 24 hours and with the addition of varying amounts of cyanide ion in the form of sodium cyanide solution. The gold concentration of the barren solution was measured to indicate the adsorption or take up of gold onto the carbon. The results are shown in Table 1. The results indicate that even for a gold:cyanide stoichiometry of 1:1.15, the gold was adsorbed quantitatively onto the carbon in all cases and except in the case of zero cyanide ion, the barren solution concentration was below the limit of measurement (<0.1 mg/l).

TABLE 1

mg CN ⁻ added	Stoichiometric Ratio Au:CN ⁻	Barren Solution Gold Conc. (mg/l)
0	0	0.8
0.4	1:1.15	<0.1
1.0	1:2.90	<0.1
2.0	1:5.80	<0.1
10.0	1:29.0	<0.1
20.0	1:58.0	<0.1
100.0	1:290	<0.1

For use in a commercial process (a) the carbon has to be reused and also (b) must be capable of high gold loadings whilst retaining loading efficiency. A further series of experiments was conducted to demonstrate the ability of carbon to adsorb the gold efficiently with increasing gold loading.

4000 mls solution containing 20% w/v Na₂SO₄, 4% w/v Na₂S₂O₃, 1% w/v Na₂CO₃, circa 7 mg/l gold (in the form of the thiosulphate anion) was mixed with 8 mg of cyanide ion in the form of sodium cyanide (which is equivalent to a gold to cyanide ion stoichiometric ratio of 1:1.2) and activated carbon. The solution was stirred at 140 rpm for 24 hours at 25°C then the carbon was screened off. This was then contacted with fresh solution and the cycle was repeated to increase gold loading. The extent of gold loading was indicated from analyses of the feed and barren solutions. After the last cycle, the carbon was separated, dried and weighed. Gold content was determined by a conventional fire assay method. The results are shown in Table 2.

TABLE 2

Cycle	Feed Solution Gold (mg/l)	Barren Solution Gold (mg/l)	'Indicated' Gold Loading (g/t)
1	3.6	0.1	350
2	3.5	<0.1	690
3	4.6	<0.1	1140
4	4.0	<0.1	1530
5	5.8	0.1	2100
6	6.4	0.1	2730
7	5.8	<0.1	3300
8	6.0	0.1	3889
9	5.8	<0.1	4460
10	5.6	<0.1	5017
11	5.2	<0.1	5532
12	5.7	<0.1	6101
13	5.2	<0.1	6623
14	5.3	<0.1	7151
15	7.5	<0.1	7896
16	6.6	<0.1	8553
17	7.2	0.3	9249
18	6.8	<0.1	9921
19	6.3	<0.1	10554
20	6.5	<0.1	11206
21	6.2	<0.1	11828
22	6.3	<0.1	12454
23	6.9	<0.1	13138
24	6.4	0.2	13763

Actual gold loading = 10,825 g/t.

A further series of experiments was carried out in which leach solutions were prepared by contacting a gold-bearing solid with ammoniacal thiosulphate solution comprising 18% ammonium thiosulphate, 3% ammonium sulphate, 2% ammonia and 4 g/l of cupric ion. The leach was carried out for 2 hours at 50°C. 500 mls of each solution were then stirred with 5 g carbon at 25°C for 17 h with 5 mg cyanide added in one test. Gold loading was based on feed and barren solution analysis.

The results were as follows:

(i) No cyanide added

Wt of carbon = 4.949 g

Feed solution 1.52 mg of gold in the form of the
thiosulphate anion/litre

Barren solution 1.45 mg of gold in the form of the
thiosulphate anion/litre

Gold Loading on carbon = 7 g/t - 5% recovery

(ii) Cyanide added

Wt of carbon = 4.961 g

Feed solution 0.95 mg of gold in the form of the
thiosulphate anion/litre

Barren solution 0.06 mg of gold in the form of the
thiosulphate anion/litre

Gold loading on carbon = 90 g/t (94% recovery)

Also experiments were carried out to show the selectivity of the process of the present invention for gold as opposed to silver. A leach solution was prepared by leaching a gold and silver containing solid with an ammoniacal thiosulphate solution comprising 18% ammonium thiosulphate, 3% ammonium sulphate, 2% ammonia and 4 g/l of cupric ion. The leach was carried out for 2 hours at 50°C. The pregnant solution was found to contain 58 mg/l of gold and 110 mg/l of silver. 500 mls of this solution was stirred with 5 g carbon and 40 mg cyanide ion for 17 h at 25°C. The carbon analysis and the barren solution concentration were then used to calculate gold loading. The analysis was as follows:

Weight of carbon = 4.646 g

Barren solution - 1.1 mg/l gold

93 mg.1 silver

Carbon loading - 4790 g/t gold

40 g/t silver

This is equivalent to a gold recovery of 97.8% and a silver recovery of 0.4%.

The gold was stripped off the loaded carbon as follows. 4 mg of loaded carbon (containing 43.57 mg of

gold) was soaked in a solution containing 5% w/v of sodium cyanide, 1% sodium hydroxide for one hour at 102°C. The solution was decanted off and the carbon refluxed with 750 mls of water at 102°C for 17 hours. The water was then decanted off and the carbon contacted with 750 mls of fresh water and refluxed for 7 hours at 102°C. The carbon was then separated and dried. All the solutions and the carbon were analysed for gold content.

The conditions used are for a standard laboratory technique for stripping gold from carbon (Zadra strip), the observed stripping efficiency of 96% being good in view of the unoptimised process.

TABLE 3

Sample	mg gold	% gold in phase	Cumulative gold %
Strip soln.	24.8	63.4	63.4
Water wash 1	10.9	27.8	91.2
Water wash 2	2.03	5.2	96.4
Carbon	1.40	3.6	100

CLAIMS

1. A process for the recovery of gold from gold-loaded thiosulphate solution comprising the steps of (a) adding to the solution at least a stoichiometric amount of cyanide ions relative to gold (b) adsorbing the resultant gold cyanide complex on an adsorbent and (c) separating the adsorbed gold from the adsorbent.
2. A process according to claim 1, wherein the gold-loaded thiosulphate solution is obtained by treatment of a gold-bearing ore with a thiosulphate solution.
3. A process according to claim 1, wherein the gold-loaded thiosulphate solution is obtained by the treatment of an oxidised residue of a refractory ore with a thiosulphate solution.
4. A process according to claim 1, wherein the gold-loaded thiosulphate solution is obtained by treating a refractory ore with oxygen and an alkaline solution.
5. A process according to claim 3 or claim 4, wherein the refractory ore is a pyritic ore.
6. A process according to claim 3 or claim 4, wherein the refractory ore is an arsenopyritic ore.
7. A process according to any one of claims 1 to 6, wherein the adsorbent is carbon.
8. A process according to claim 7, wherein the carbon is an activated carbon.

9. A process according to any one of claims 1 to 6, wherein the adsorbent is a resin.

10. A process according to any one of claims 1 to 9, wherein the adsorbed gold is separated from the adsorbent by the Zadra stripping process.

11. A process according to any one of claims 1 to 10, wherein cyanide ions are added in an amount corresponding to from 1 to about 400 times the cyanide:gold stoichiometric ratio.

12. A process according to claim 11, wherein cyanide ions are added in an amount corresponding to from 1 to about 10 times the cyanide:gold stoichiometric ratio.

13. A process according to any one of claims 1 to 12, wherein the gold-loaded thiosulphate solution up to 6% w/v $\text{Na}_2\text{S}_2\text{O}_3$.

14. A process according to any one of claims 1 to 13, wherein the gold-loaded thiosulphate solution contains at one or more of the following components, viz.:

- (a) up to about 25% w/v Na_2SO_4 ; and/or
- (b) up to about 5% w/v Na_2CO_3 ; and/or
- (c) up to about 10% w/v NaOH .

15. A process according to any one of claims 1 to 14, wherein the thiosulphate solution contains from about 1 to about 10 mg/l gold (in the form of the thiosulphate anion).

16. A process for the selective recovery of gold from a thiosulphate-containing feed solution containing at least one

further metal selected from silver, copper, zinc and mixtures thereof, comprising the steps of:

- (a) adding to the feed solution at least a stoichiometric amount of cyanide ions relative to gold;
- (b) adsorbing the resultant gold cyanide complex on an adsorbent thereby to produce (i) a gold-loaded adsorbent bearing a substantial proportion of the gold present in the feed solution and at most a minor proportion of said at least one other metal present in the feed solution and (ii) a barren liquor containing substantially all of said at least one other metal present in the feed solution and at most a minor proportion of the gold present in the feed solution;
- (c) separating the gold-loaded adsorbent from the barren liquor; and
- (d) separating the adsorbed gold from the adsorbent.

INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 91/00114

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) ⁶ According to International Patent Classification (IPC) or to both National Classification and IPC IPC ⁵ : C 22 B 3/42, C 22 B 11/08														
II. FIELDS SEARCHED <div style="text-align: right; font-size: small;">Minimum Documentation Searched ⁷</div> <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 30%; padding: 5px;">Classification System</td> <td style="padding: 5px;">Classification Symbols</td> </tr> <tr> <td style="padding: 5px;">IPC⁵</td> <td style="padding: 5px;">C 22 B</td> </tr> </table> <div style="text-align: center; font-size: x-small; margin-top: 5px;">Documentation Searched other than Minimum Documentation to the extent that such Documents are included in the Fields Searched ⁸</div>			Classification System	Classification Symbols	IPC ⁵	C 22 B								
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III. DOCUMENTS CONSIDERED TO BE RELEVANT ⁹ <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <th style="width: 10%; padding: 5px;">Category ⁹</th> <th style="width: 70%; padding: 5px;">Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²</th> <th style="width: 20%; padding: 5px;">Relevant to Claim No. ¹³</th> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">Y</td> <td style="padding: 5px;">US, A, 4654079 (NUNEZ et al.) 31 March 1987 see claim 1 --</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1,4</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">Y</td> <td style="padding: 5px;">US, A, 4369061 (KERLEY, Jr.) 18 January 1983 see claim 1 cited in the application --</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1,4</td> </tr> <tr> <td style="text-align: center; vertical-align: top; padding: 5px;">Y</td> <td style="padding: 5px;">Hydrometallurgy, vol. 19, no. 3, January 1988, Elsevier Science Publishers B.V., (Amsterdam, NL), D. Zipperian et al.: "Gold and silver extraction by ammoniacal thiosulfate leaching from a rhyolite ore", pages 361-375 see page 364, lines 18-22; page 365, lines 1-25; page 366, lines 1-8; page 367, lines 1-3 -- ./.</td> <td style="text-align: center; vertical-align: top; padding: 5px;">1-8,16</td> </tr> </table>			Category ⁹	Citation of Document, ¹¹ with indication, where appropriate, of the relevant passages ¹²	Relevant to Claim No. ¹³	Y	US, A, 4654079 (NUNEZ et al.) 31 March 1987 see claim 1 --	1,4	Y	US, A, 4369061 (KERLEY, Jr.) 18 January 1983 see claim 1 cited in the application --	1,4	Y	Hydrometallurgy, vol. 19, no. 3, January 1988, Elsevier Science Publishers B.V., (Amsterdam, NL), D. Zipperian et al.: "Gold and silver extraction by ammoniacal thiosulfate leaching from a rhyolite ore", pages 361-375 see page 364, lines 18-22; page 365, lines 1-25; page 366, lines 1-8; page 367, lines 1-3 -- ./.	1-8,16
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<div style="display: flex; justify-content: space-between; font-size: x-small;"> <div style="width: 45%;"> <p>⁹ Special categories of cited documents: ¹⁰</p> <p>"A" document defining the general state of the art which is not considered to be of particular relevance</p> <p>"E" earlier document but published on or after the international filing date</p> <p>"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)</p> <p>"O" document referring to an oral disclosure, use, exhibition or other means</p> <p>"P" document published prior to the international filing date but later than the priority date claimed</p> </div> <div style="width: 45%;"> <p>"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention</p> <p>"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step</p> <p>"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art</p> <p>"G" document member of the same patent family</p> </div> </div>														
IV. CERTIFICATION <table border="1" style="width: 100%; border-collapse: collapse;"> <tr> <td style="width: 50%; padding: 5px;"> Date of the Actual Completion of the International Search 25th April 1991 </td> <td style="width: 50%; padding: 5px;"> Date of Mailing of this International Search Report 13. 06. 91 </td> </tr> <tr> <td style="padding: 5px;"> International Searching Authority EUROPEAN PATENT OFFICE </td> <td style="padding: 5px;"> Signature of Authorised Officer TORIBIO </td> </tr> </table>			Date of the Actual Completion of the International Search 25th April 1991	Date of Mailing of this International Search Report 13. 06. 91	International Searching Authority EUROPEAN PATENT OFFICE	Signature of Authorised Officer TORIBIO								
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International Searching Authority EUROPEAN PATENT OFFICE	Signature of Authorised Officer TORIBIO													

III. DOCUMENTS CONSIDERED TO BE RELEVANT (CONTINUED FROM THE SECOND SHEET)		
Category *	Citation of Document, " with indication, where appropriate, of the relevant passages	Relevant to Claim No.
Y	EP, A, 0177291 (SHERRITT GORDON MINES LTD) 9 April 1986 see claims 1-13,15 --	1-8,16
A	US, A, 4269622 (KERLEY, Jr.) 26 May 1981 see claim 1 cited in the application --	1-3
A	US, A, 4070182 (GENIK-SAS-BEREZOWSKY et al.) 24 January 1978 see claim 1 cited in the application --	1
A	US, A, 3920403 (ROSS) 18 November 1975 see claim 1 cited in the application --	7,8,10
A	Reactive Polymers, vol. 9, no. 3 + index, December 1988, Elsevier Science Publishers B.V., (Amsterdam, NL), J.H. Hodgkin et al.: "Gold extraction with poly(diallylamine) resins", pages 285-291 see page 287, right-hand column, lines 9-36; page 289, right-hand column, lines 18-24; page 290, left-hand column, lines 1-5 -----	9

**ANNEX TO THE INTERNATIONAL SEARCH REPORT
ON INTERNATIONAL PATENT APPLICATION NO.**

GB 9100114

SA 43835

This annex lists the patent family members relating to the patent documents cited in the above-mentioned international search report. The members are as contained in the European Patent Office EDP file on 31/05/91
The European Patent Office is in no way liable for these particulars which are merely given for the purpose of information.

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US-A- 4654079	31-03-87	None	
US-A- 4369061	18-01-83	US-A- 4269622	26-05-81
		CA-A- 1148748	28-06-83
EP-A- 0177291	09-04-86	CA-A- 1234991	12-04-88
		AU-B- 569417	28-01-88
		AU-A- 4789485	10-04-86
		JP-A- 61179823	12-08-86
		US-A- 4571264	18-02-86
US-A- 4269622	26-05-81	CA-A- 1148748	28-06-83
		US-A- 4369061	18-01-83
US-A- 4070182	24-01-78	CA-A- 1073681	18-03-80
		AU-B- 499658	26-04-79
		AU-A- 2246177	24-08-78
US-A- 3920403	18-11-75	None	